



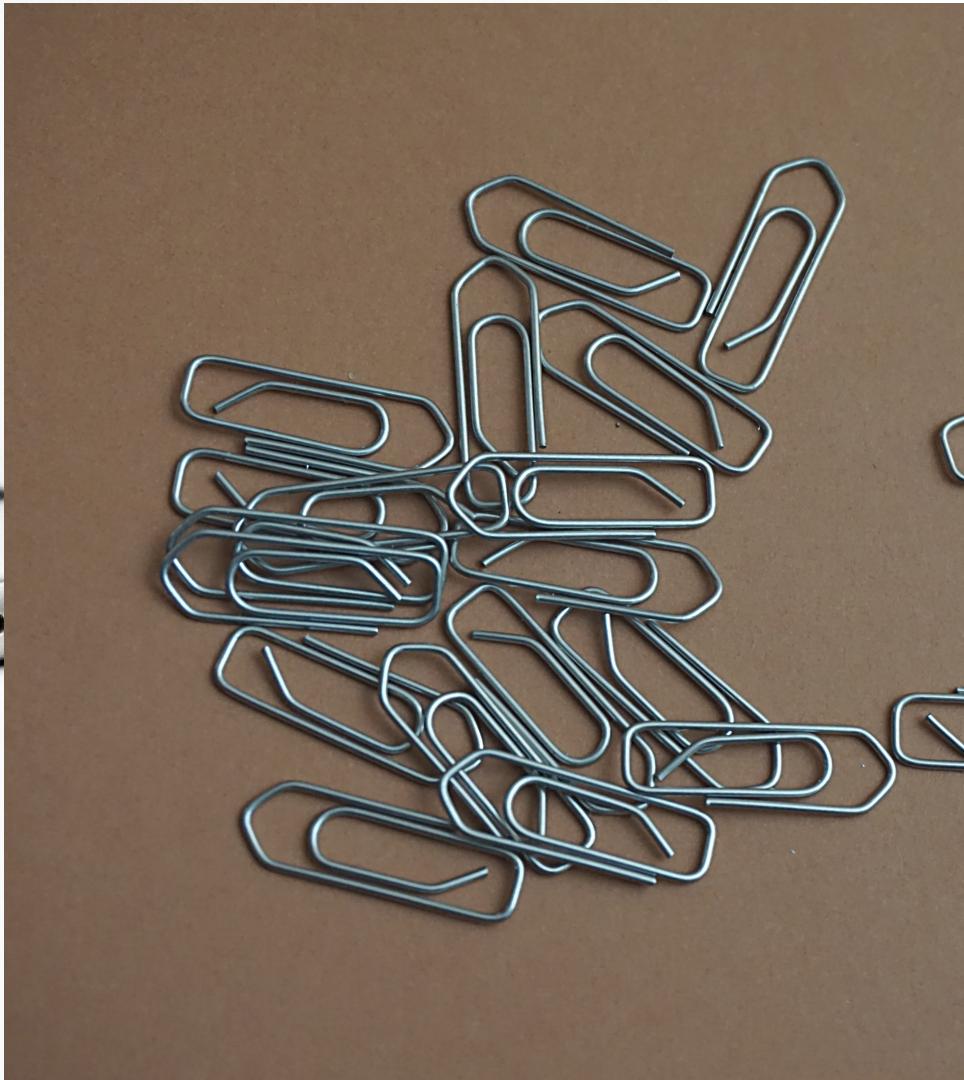
Maschinelles Lernen auf unbekannten Terrain

am Beispiel von Spotify's “Discover Weekly”

Nico Kreiling

Karlsruhe, 25.4.2018







Nico Kreiling

- › Big Data Scientist @ inovex
- › Neugierig und Tech-Begeistert
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- › Musik Fan

ECK'S

HSIDE
IVAL



Schwäbische Zeitung

AL 2017



SOU

Festival



Discover **Weekly**







Gefällt dir Kokowäh?!

Ja! Ich mag auch
Zweiohrküken,
Keinohrhasen, Hotdog
und den Tatort mit dir..

Dann schau dir noch „der
rote Baron“ an!



Wir stehen für Sicherheit,
Fortschritt, Familie,
Heimat..

...und natürlich soziale
Gerechtigkeit.

Aber wir haben
soziale
Gerechtigkeit

Aber das sind doch
unsere Themen...

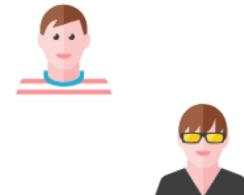
Collaborative Filtering

1. Bewertungsmatrix erstellen
2. Ähnliche Nutzer finden
3. Prognosen berechnen

1. Matrix erstellen



3
2
4
1,5



5
4
1,5
2,5
4



1. Matrix erstellen

					
		3	5	2	?
		2	4	3	3
		4	1,5	4,5	4,5
		?	2,5	3	4
		1,5	5	?	3,5

2. Ähnliche Nutzer finden

	3	5
	2	4
	4	1,5
	?	2,5
	1,5	5

Pearson Korrelationskoeffizient bestimmen:

$$r = \frac{\sum_{i=1}^n (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^n (x_i - \bar{x})^2} \cdot \sqrt{\sum_{i=1}^n (y_i - \bar{y})^2}}$$

$$\bar{x} = 2.625 \quad \bar{y} = 3,875$$

$$\frac{(3-\bar{x})*(5-\bar{y})+ \dots}{\sqrt{(3-\bar{x})^2 + \dots + (1,5-\bar{x})^2} + \dots} = \frac{-4.187}{5.494} = -0.762$$

3. Prognose Werte Berechnen



$$\frac{\sum_{\text{Nutzer}} \text{Bewertung} * \text{Ähnlichkeit}}{\sum_{\text{Nutzer}} \text{Bewertung}}$$

$$\frac{2,5 * -0,7621 + \dots + 4 * 0,866}{-0,7621 + 0,596 + 0,866} = \frac{3,34}{0,69}$$



4.7816

2,5

3

4



1

-0,7621

0,596

0,866

Unterschiedliche Anwendung

Netflix	Spotify
60.000 Filme	20 Mio Lieder
Einmaliger Konsum	Wiederholender Konsum
Vor allem Blockbuster	Stärker Nischen-Konsum

Rating Model

$$\min_{x,y} \sum_{u,i} (r_{ui} - x_u^T y_i - b_u - b_i)^2 - \lambda \left(\sum_u \|x_u\|^2 + \sum_i \|y_i\|^2 \right)$$

- r_{ui} = user u 's rating for movie i
- x_u = user u 's latent factor vector
- y_i = item i 's latent factor vector
- b_u = bias for user u
- b_i = bias for item i
- λ = regularization parameter

Binary Stream Model

$$\min_{x,y} \sum_{u,i} c_{ui} (p_{ui} - x_u^T y_i - b_u - b_i)^2 - \lambda \left(\sum_u \|x_u\|^2 + \sum_i \|y_i\|^2 \right)$$

- $p_{ui} = 1$ if user u streamed track i else 0
- $c_{ui} = 1 + \alpha r_{ui}$
- x_u = user u 's latent factor vector
- y_i = item i 's latent factor vector
- b_u = bias for user u
- b_i = bias for item i
- λ = regularization parameter



Collaborative Filtering

- Generelles Empfehlungsverfahren
- Inhaltsunabhängig
- weit verbreitet
- Cold-Start-Problem

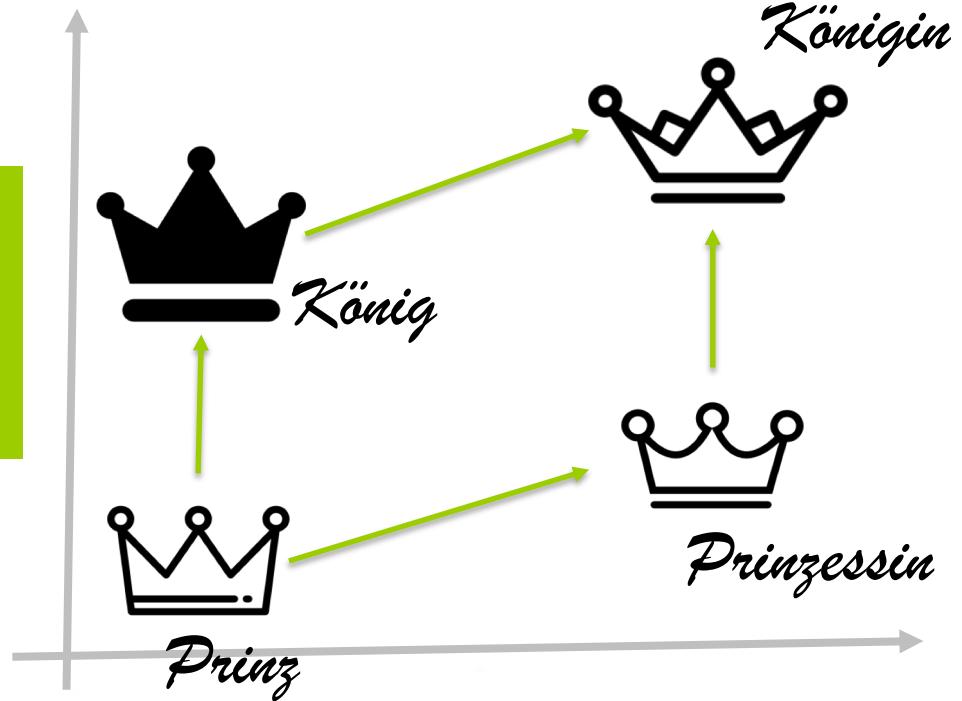


Vector Representation

$$\text{König} - \text{Königin} = \text{Prinz} - \text{Prinzessin}$$

\Leftrightarrow

$$\text{König} - \text{Königin} + \text{Prinzessin} = \text{Prinz}$$



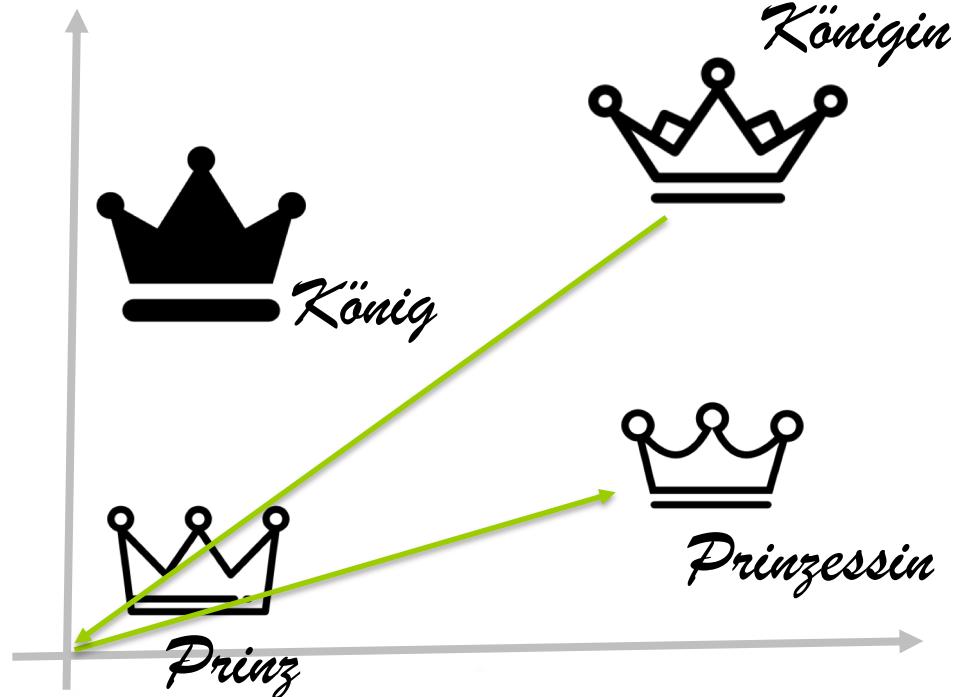
Vector Representation

König

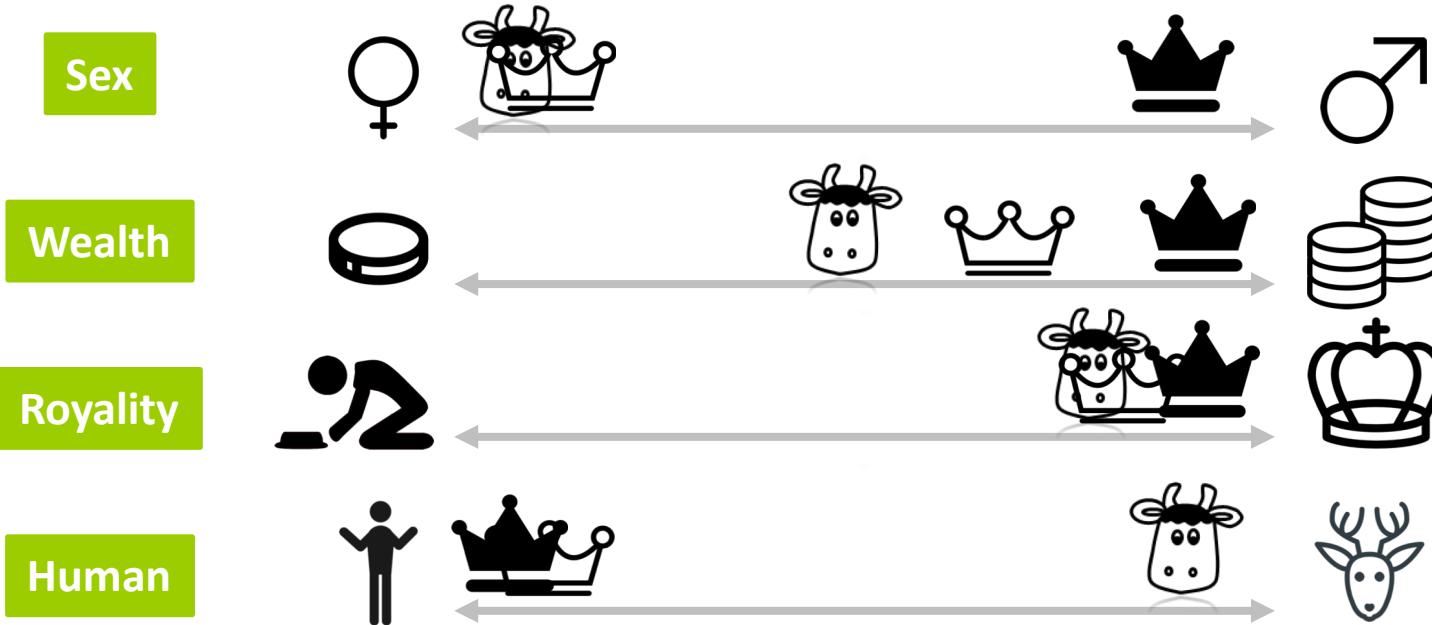
+ Prinzessin

- Königin

= Prinz



Dimensionalitätsraum



Word Embeddings

Hidden Feature	König	Königin	Prinzessin	König +Prinzessin -Prinz	Kuh	Prinz
Male	1	-1	-1	1	- 0,98	0,97
Human	1	1	1	1	-1	1
Rich	0,99	0,98	0,3	0,3	0,01	0,34
Blue Blood	0,98	1	0,99	0,99	0,12	1

Word2Vec – Selbst erstellen

We will, we **will** rock you

1. Wörter trennen
2. Co-Occurrence Matrix erstellen
3. Latent Features durch Dimensionalitätsreduktion
 - **CBOW: (we, rock) => will**
 - Skip-Grams: (will) => (we, rock)



Input

Hidden

Output

	we	will	rock	you
we		1		
will	2			
we		2		
will	1		1	
rock		1		1
you			1	

the worries Woolard already had from watching Amelio bumble the shareholders meeting.

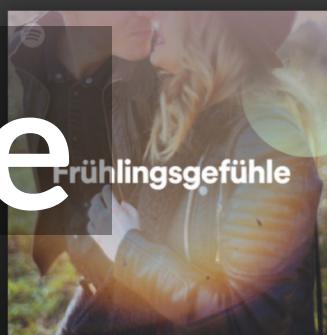
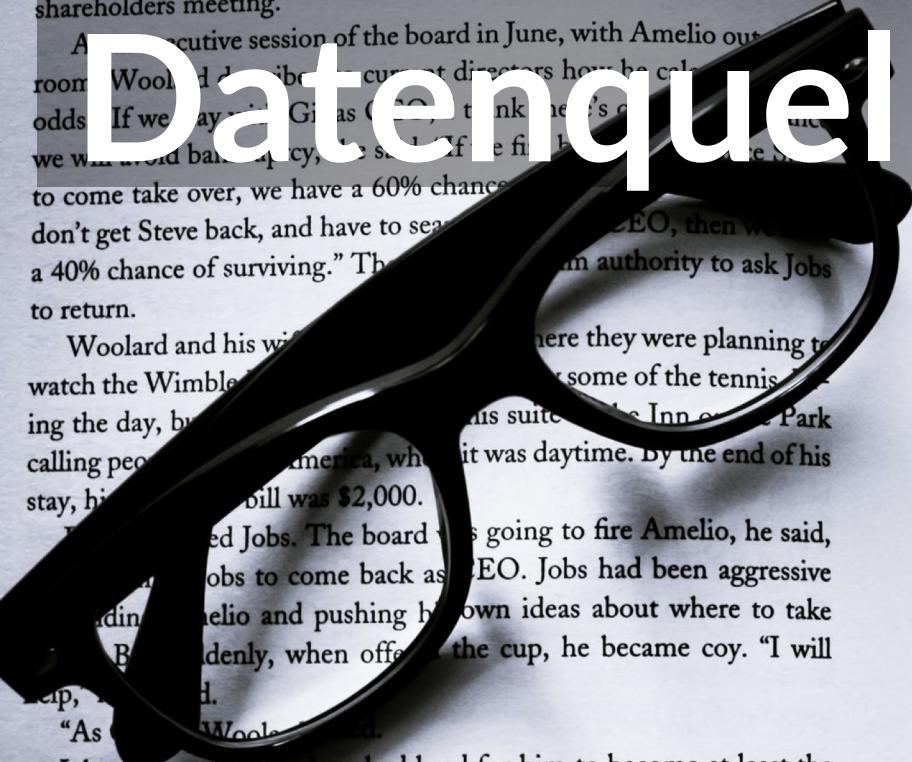
A executive session of the board in June, with Amelio out room Woolard described current directors how he could odds. If we stay with Giacomo, I think there's a chance we will avoid bankruptcy," he said. "If the financials are to come take over, we have a 60% chance don't get Steve back, and have to seek a new CEO, then we a 40% chance of surviving." The board has the authority to ask Jobs to return.

Woolard and his wife, Linda, had been invited to where they were planning to watch the Wimbledon men's final. They had some of the tennis tickets for the day, but had to leave his suite at the Inn on the Park calling people in America, when it was daytime. By the end of his stay, his hotel bill was \$2,000.

For Jobs, it seemed Jobs. The board was going to fire Amelio, he said, and asked Jobs to come back as CEO. Jobs had been aggressive in defending Amelio and pushing his own ideas about where to take Apple. But suddenly, when offered the cup, he became coy. "I will help, I said.

"As you like," Woolard said.

Jobs said no. Woolard pushed hard for him to become at least the acting CEO. Again Jobs demurred. "I will be an advisor," he said. "Unpaid." He also agreed to become a board member—that was something he had yearned for—but declined to be the board chairman. "That's all I can give now," he said. After rumors began circulating, he emailed a memo to Pixar employees assuring them that he was not abandoning them. "I got a call from Apple's board of directors three weeks ago asking



PLAYLIST

Frühlingsgefühle

Ganz vorsichtig streckt der Frühling seine Fühler aus. Mit dem die passende Stimmung.

Created by Spotify • 67 songs, 3 hr 58 min

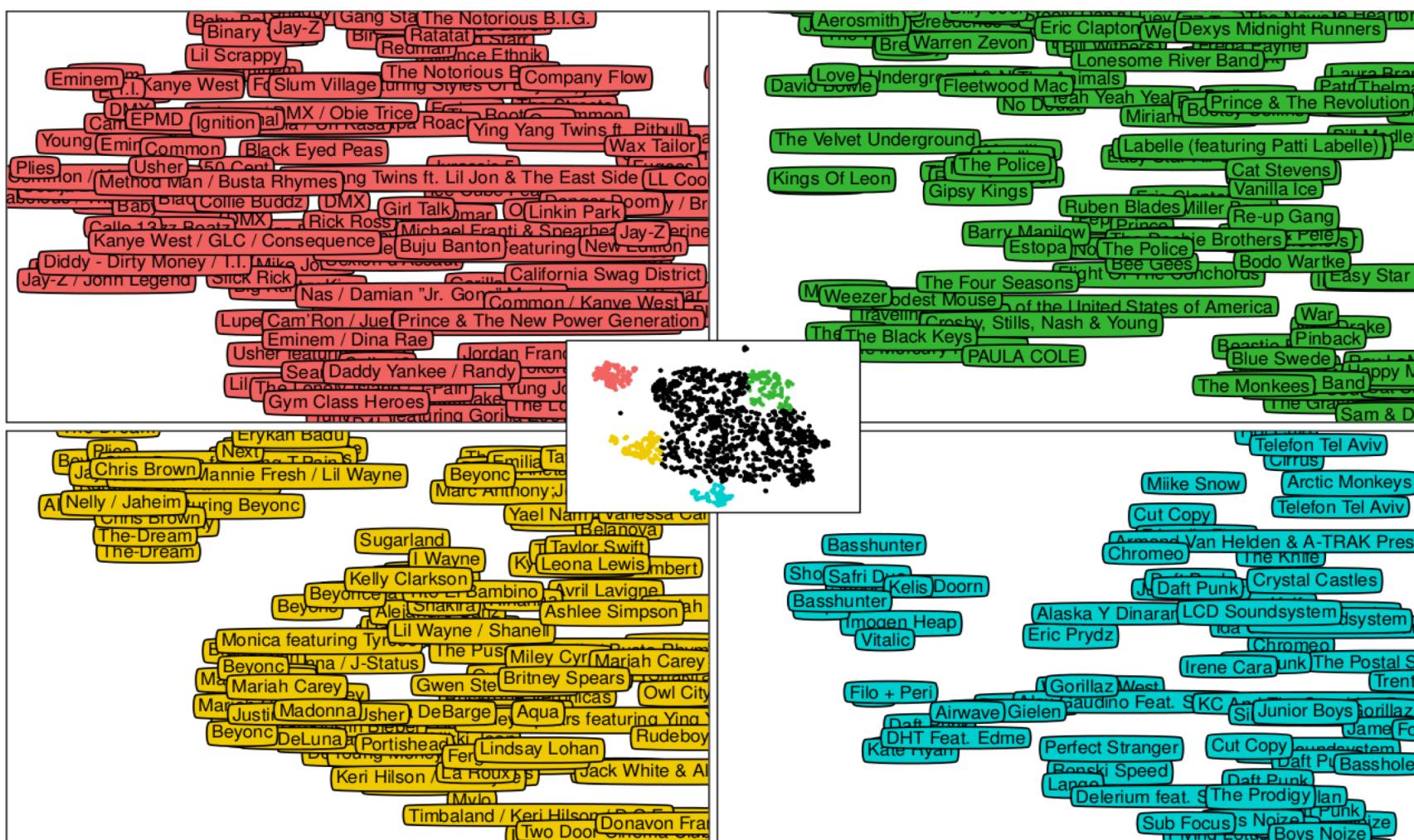
PLAY

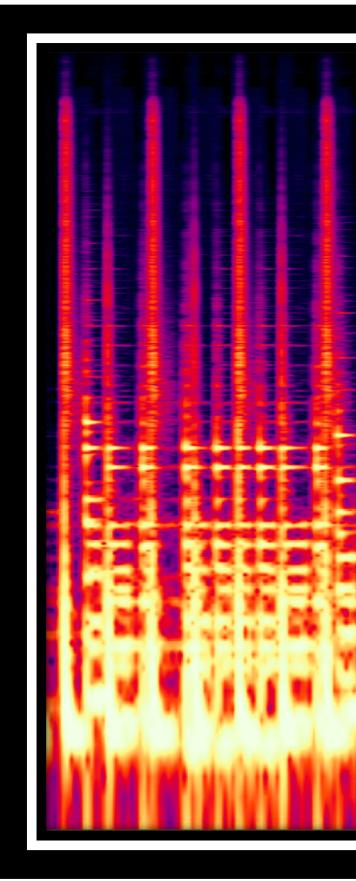
FOLLOWING



Q Filter

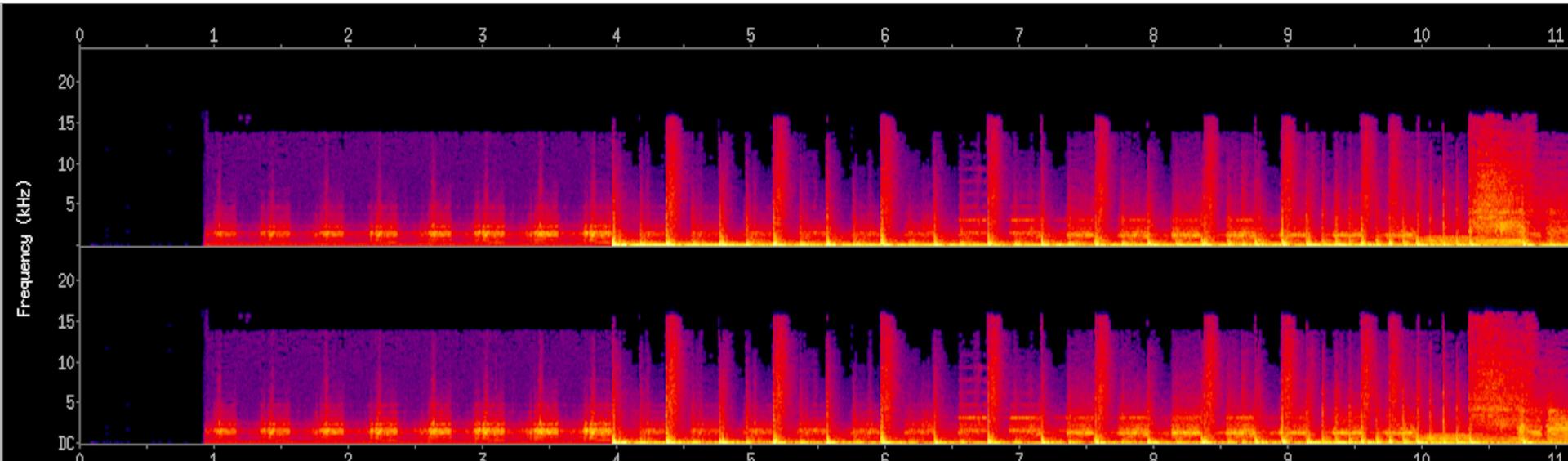
TITLE	ARTIST
+ Hurt Somebody	Noah Kahan, Julia Michaels
+ islands_	Blaudzun
+ Run to You	Tom Gregory
+ Lonely Together - Acoustic	Avicii, Rita Ora
+ Too Much To Ask	Niall Horan
+ Work On Me	The Tech Thieves
+ Be Your Love	Bishop Briggs
+ Waiting Here	Jake Isaac
+ Leave a Light On	Tom Walker
+ Nevermind	Dennis Lloyd





Ton zu Bild

```
sox ./banquet.mp3 -c 1 -n spectrogram -Y 500 -X 100 -o ./ab.png
```

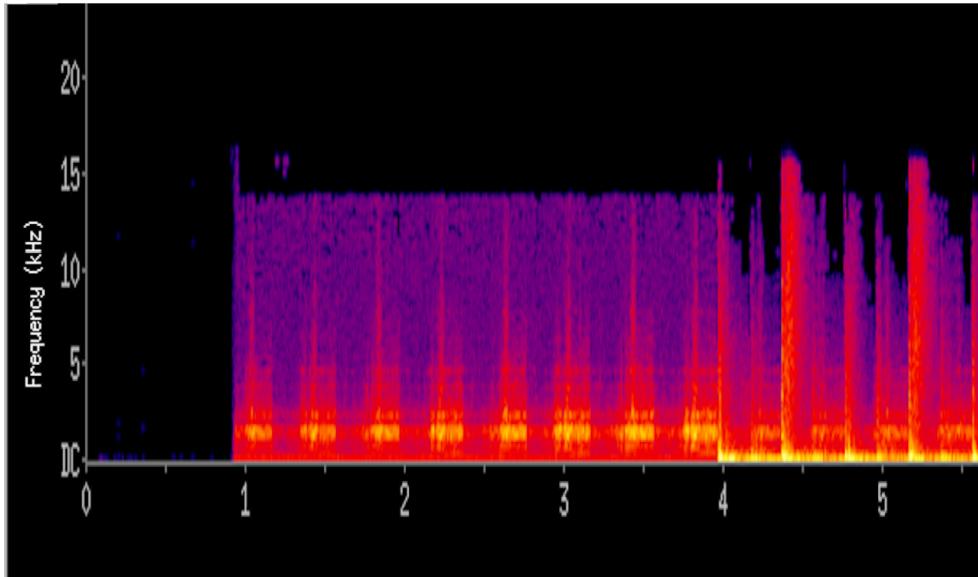




Vor allem Quadratische Eingangsdaten

Features abhängig von Position im Bild

Bilder vor allem als ganzes aussagekräftig

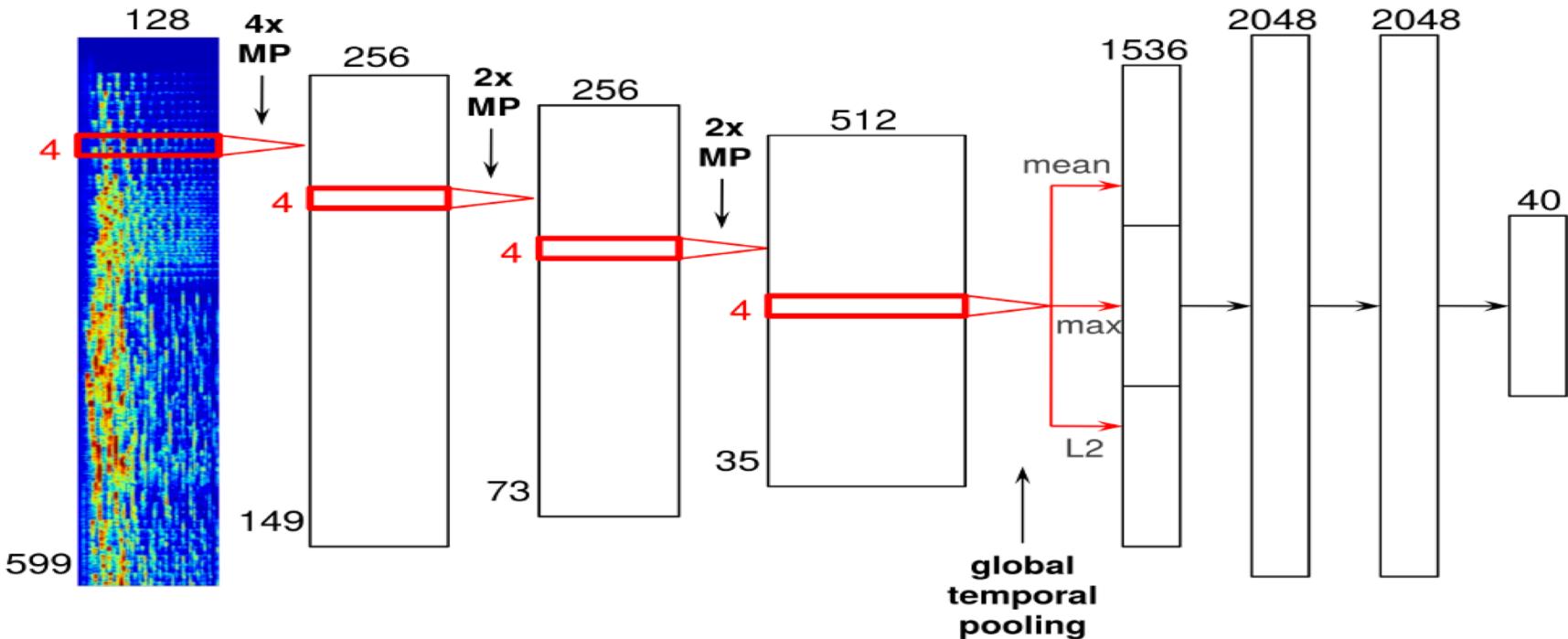


Unterschiedliche semantische Bedeutung
der Eingangsdaten (Zeit & Frequenz)

Features unabhängig von ihrer Position

Teilbereiche des Audios häufig ausreichend

CNNs für Audio



Filter 1: noise, distortion



low-level #1 (mean): nois...



- 1 I've Seen the Future and It's No Pi... 1:13
Cold Cave
- 2 Landscape 3:37
Weekend
- 3 Dazed And Confused - 23/3/69 T... 6:39
Led Zeppelin
- 4 Guitar Solo - Live 4:43
Ozzy Osbourne
- 5 Blacks/Radio 6:56
The Psychedelic Furs
- 6 cloud #1 2:06
Thee Oh Sees

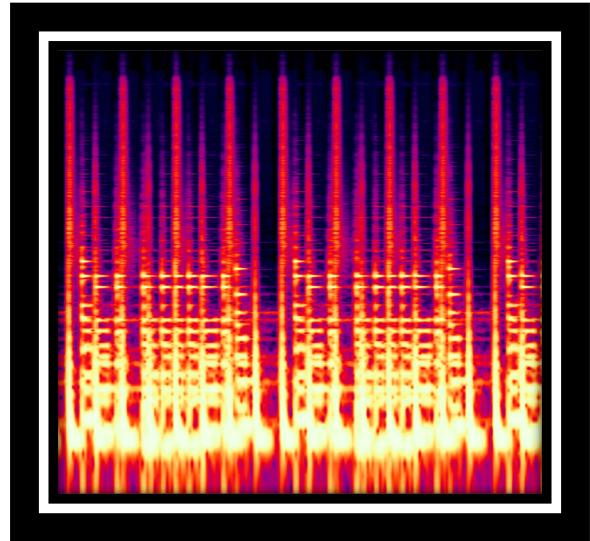
Filter 2: pitch (A, Bb)



low-level #2 (mean): pitc...



- 1 Amazing Grace 2:46
The Scottish Bagpipe Players
- 2 Solo Pipes: I. The Stirlingshire Mil... 4:22
2nd Battalion Scots Guards
- 3 Cello Drone Bb 6:00
Musician's Practice Partner
- 4 Scotland The Brave / Rowan Tree... 3:07
The Scottish Bagpipe Players
- 5 Radhe 7:26
Wah!
- 6 Bland bergen i Glencoe 4:21
Björn Afzelius



Wie kriegt man Machine Learning auf neues Terrain?



IS YOUR
STARTUP
IDEA
TAKEN?

	UBER	TINDER	BIRCHBOX	AIRBNB
DOGS	WAG!	BARKBUDDY	BARKBOX	DOGVACAY
FOOD	POSTMATES	NOMLY	BLUE APRON	EATWITH
WEED	EAZE	HIGH THERE	POTBOX	BUD AND BREAKFAST
LAUNDRY	WASHO			LAUNDERMATIC
PARKING	MONKEY PARKING			SPOT PARK
MASSAGE	ZEEL			
BEARDS		BRISTLR	DOLLAR BEARD CLUB	
STORAGE	CLUTTER			ROOST
BOATS	BOATERBUND			ANTLUS
DRONES	ANIMAL ROBO			DRONEIS
PARTIES		KICKIN		EVENTUP
ELITISTS	BLADE	THE LEAGUE	OPULENCE BOX	ONE FINE STAY
DOCTORS	HEAL			
MOVING	LUGG			
ALCOHOL	MIMBAR		GLASSFUL	
COFFEE	CLOWDER		CRAFT COFFEE	
BODY FLUIDS			LOLA	AIRBNB
WORKSPACE	BREATHER			SPACE CHAIR
SHOPPING	SHYP			
FLOWERS	BLOOMTHAT		THE BOODS	
JOBS	TASKRABBIT	SWITCH		
GAMERS		MILLENNIAL SWIPE SIM	LOOT CRATE	
PIZZA	PUSHFOR PIZZA			
CONDIMENTS			SHIP AND DIP	
UNDERWEAR			MEUNDIES	
SOCKS			SOCK FANCY	
KIDS	SHOOLE		CITRUS LANE	
SHOES		SHOE SWIPE	SHOEDAZZLE	
CAMPING				HPCAMP
ADULT FUN	DEALALA	MIXXIER	UNDEON	KINKING



TAKEN

AVAILABLE



IS YOUR
STARTUP
IDEA
TAKEN?

→ UBER TINDER BIRCHBOX AIRBNB

DOGS	WAG!	BARKBUDDY	BARKBOX	DOGVACAY
FOOD	POSTMATES	NIBBLY	BLUE APRON	EATWITH
WEED	EAZE	HIGH THERE	POTBOX	BUD AND BREAKFAST
LAUNDRY	WASHIO			LAUNDROMATCH
PARKING	MONKEY PARKING			SPOT PARK
MASSAGE	ZEEL			

Spotify hackerweek

Come up with ideas how to use stuff



Vielen Dank

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